REMARKS

Applicants have amended their claims in order to further clarify the definition of various aspects of the present invention. Specifically, Applicants have amended each of independent claims 59, 62, 85 and 89 to delete the "adapted to" expression at lines 1-3 of each of these claims, and to recite instead, in the main body of these claims, that the polishing medium has the property of being capable of polishing a barrier layer of tantalum, a tantalum alloy or a tantalum compound, which is a barrier layer for a conductor of copper, copper alloy or copper oxide. Claims 65, 69, 93 and 97 have been amended to delete the expression "for chemical-mechanical polishing ..." in lines 1 and 2 of each of these claims, and to insert in the main body of these claims that the polishing medium has the property of being capable of chemical-mechanical polishing a surface having at least one of tantalum, tantalum alloy and tantalum compound.

Moreover, Applicants have cancelled non-elected claims 40, 52, 53, and 73-84 without prejudice or disclaimer, and, in particular, without prejudice to the filing of a Divisional application directed to the subject matter thereof.

Applicants note the contention by the Examiner in Item 7 on page 5 of the Office Action mailed August 11, 2005, that he "has not found the enclosed Declaration under 37 CFR 1.132". Please note that an additional copy of this Declaration was submitted in the Request For Clarification And For Complete Office Action filed September 6, 2005. Unfortunately, the Examiner has not responded to this Request For Clarification And For Complete Office Action. It is respectfully submitted that he Examiner must comment upon the Declaration, in order to provide a complete Office Action to this Amendment. Moreover, and as will be discussed further infra, in view of present amendments to the claims wherein the capability of

polishing tantalum, tantalum alloy or a tantalum compound is recited as a property of the medium, in the main body of claims, the Examiner must give this Declaration weight, in determining patentability.

The rejection of Applicants' claims under the first paragraph of 35 USC 112, as failing to comply with the written description requirement, the Examiner contending that it is unclear wherein the Specification teaches that the polishing medium is for a tantalum compound, set forth in Item 9 on page 6 of Applicants' Specification, is noted. The Examiner's attention is respectfully directed to, for example, page 6, lines 1-16, of Applicants' specification, describing, inter alia, a layer of tantalum, tantalum alloy, "tantalum nitride or other tantalum compound" being formed as a barrier layer to copper or copper alloy of the wiring. Note also the paragraph bridging pages 7 and 8 of Applicants' Specification, referring to tantalum, tantalum alloy and tantalum compound; the last full paragraph on page 8, describing polishing of the tantalum, tantalum alloy, tantalum nitride and other tantalum compounds; the paragraph bridging pages 12 and 13, disclosing that the conductor suited for the polishing making use of a polishing medium for chemical-mechanical polishing of the present invention "may include copper, copper alloys and copper oxides, and tantalum, tantalum alloys and tantalum compounds (such as tantalum nitride) which constitute barrier layers for the former (layers for preventing copper atoms from diffusing)"; and the last two paragraphs on page 15 of Applicants' Specification, as well as numerous other descriptions in Applicants' Specification referring to, for example, "tantalum nitride or other tantalum compounds". Clearly, Applicants' original disclosure as a whole describes that the polishing medium is for, inter alia, a tantalum compound, as well as tantalum and tantalum alloy, such that the Specification reasonably conveys to one of ordinary skill in the relevant art that

the inventors, at the time the above-identified application was filed, had possession of the claimed invention, including that the polishing medium has a property of polishing tantalum compounds. Clearly, the Examiner errs in the rejection of the present claims being considered on the merits, as failing to comply with the written description requirement. Reconsideration and withdrawal of this rejection is respectfully requested.

The rejection of various of the claims being considered on the merits in the above-identified application under the second paragraph of 35 USC 112, as being indefinite, set forth in Item 11 on page 6 of the Office Action mailed August 11, 2005, is respectfully traversed, especially insofar as applicable to the claims as presently amended. Thus, claims 59, 62, 85 and 89 have been amended to recite that the polishing medium has a property of being capable of polishing a barrier layer of tantalum, a tantalum alloy or a tantalum compound, which is a barrier layer for a conductor of copper, copper alloy or copper oxide. It is respectfully submitted that claims 59, 62, 85 and 89 as presently amended sufficiently clearly define a property of the polishing medium (that is, having the property of polishing the specified barrier layer), defining what the barrier layer is a barrier layer for, so as to satisfy requirements of the second paragraph of 35 USC 112. Thus, in connection with claims 59, 62, 85 and 89, as well as claims dependent thereon, it is respectfully submitted that one of ordinary skill in the art would know whether any specific polishing medium fell within or outside the scope of the present claims. It is respectfully submitted that under the present circumstances, the second paragraph of 35 USC §112 requires nothing more. See In re Moore, 169 USPQ 236 (CCPA 1971).

It is respectfully submitted that all of the claims presented for consideration by the Examiner patentably distinguish over the teachings of the prior art applied by the Examiner in rejecting claims in the Office Action mailed August 11, 2005, that is, the teachings of the U.S. patents to Lee, et al., No. 6,171,352, and to Hardy, et al., No. 6,238,592, under the provisions of 35 USC 103.

It is respectfully submitted that the references as applied by the Examiner would have neither disclosed nor would have suggested such polishing medium as in the present claims, with or without abrasive grains, with the medium including, inter alia, an oxidizing agent, a protective-film-forming agent, an acid and water, wherein the polishing medium has a pH of 3 or less and includes the oxidizing agent in a concentration of from 0.01% by weight to 3% by weight, and wherein the polishing medium has a property of polishing a barrier layer of tantalum, a tantalum alloy or a tantalum compound, which is a barrier layer for a conductor of copper, copper alloy or copper oxide. See claims 59 and 62. Note also claims 85 and 89, reciting specific materials in the medium.

Moreover, it is respectfully submitted that the applied references would have neither disclosed nor would have suggested such polishing medium as in the present claims, as discussed previously in connection with claim 62, and including abrasive grains, and wherein the abrasive grains have an average particle diameter of 50 nm or less and the abrasive grains have a standard deviation of particle size distribution in a value of more than 5 nm. See claim 25.

Furthermore, it is respectfully submitted that the applied references would have neither taught nor would have suggested such polishing medium as in the present claims, having features as discussed previously in connection with claim 62 (including the abrasive grains), and wherein the medium further includes a water-

soluble polymer, with the concentration of oxidizing agent in the polishing medium being in a range of from 0.01% by weight to 1.8 % by weight. Note, for example, claim 27; see also claim 42.

In addition, it is respectfully submitted that these references as applied by the Examiner would have neither taught nor would have suggested such a polishing medium as in the present claims, with this medium including, inter alia, an oxidizing agent, protective-film-forming agent and acid, with or without abrasive grains, and wherein the polishing medium has a pH of 3 or less and the oxidizing agent is included therein in a concentration of from 0.01% by weight to 3.0% by weight, and wherein the polishing medium has the property of being capable of chemical-mechanical polishing a surface having at least one of tantalum, tantalum alloy and a tantalum compound. See claims 65 and 69. Note also claims 93 and 97, reciting specific materials of the medium.

Furthermore, it is respectfully submitted that the teachings of the applied references would have neither disclosed nor would have suggested the polishing medium for chemical-mechanical polishing having components as referred to previously, and having a polishing-rate ratio of tantalum-containing material to copper-containing material that is greater than 1 (see, e.g., claims 60 and 63; note also claims 38 and 51, reciting this polishing rate between tantalum-containing material and copper-containing material, and between tantalum-containing material and silicon dioxide, which would have neither been disclosed or suggested by the teachings of the applied references).

Moreover, it is respectfully submitted that the teachings of the applied prior art would have neither disclosed nor would suggested the other aspects of the present invention as in the remaining, dependent claims, being considered on the merits,

including (but not limited to) the amount of abrasive grains mixed into the polishing medium, as in, for example, claim 26; and/or wherein the oxidizing agent is included in the polishing medium in a concentration of from 0.01% by weight to 1.5% by weight (note, for example, claim 29; see also claims 44, 68, 72, 88, 92, 96 and 100); and/or wherein the acid of the polishing medium is an organic acid (see, e.g., claim 30), in particular, wherein such acid is at least one selected from the group thereof set forth in claim 31.

Moreover, attention is again directed to the Declaration under 37 CFR 1.132 of Mr. Y. Kurata, one of the named inventors in the above-identified application, providing evidence of unexpectedly better results achieved according to the present invention, including ranges of amount of oxidizing agent, and pH of the medium as in the present claims. This Declaration was submitted with the Submission (Amendment) filed June 6, 2005, and an additional copy was submitted with the Request For Clarification filed September 6, 2005. As discussed infra, it is respectfully submitted that this evidence establishes unexpectedly better results achiev3ed by the present invention, so as to clearly support a conclusion of unobviousness of the presently claimed subject matter. Note Manual of Patent Examining Procedure (MPEP) 2131.03, sub-section II.

The present invention, as being considered on the merits herein, is directed to a polishing medium for chemical-mechanical polishing, useful with or without abrasive grains, additional aspects of the present invention including further improvements when the medium includes abrasive grains,.

In metal formation such as in the formation of damascene wirings of copper or copper alloy or the formation of plug wirings of tungsten, a phenomenon called "thinning" in which the thickness of wiring becomes small together with an

interlaminar insulating film may occur when an interlaminar insulating film of, e.g., silicon dioxide, is polished at a rate close to the rate of polishing the metal film. As a result, there may be caused an increase in wiring resistance or a non-uniformity in resistance ascribable to pattern density. Hence, it is desired that the polishing medium for chemical-mechanical polishing has a property that the polishing rate of a silicon dioxide film is sufficiently smaller than that of the metal film to be polished. Note the last paragraph on page 5 of Applicants' specification.

It is also desired that in performing the metal polishing, "dishing" of the surface of the metal wiring, wherein the surface becomes hollow at the middle thereof like a dish, resulting in a bad effect on flattening, be avoided.

In chemical-mechanical polishing of, e.g., a layer of copper or copper alloy of wiring, together with polishing of, e.g., a layer of tantalum, tantalum alloy, tantalum nitride or other tantalum compound as a barrier layer (tantalum being most commonly used as a barrier metal film), a two-step polishing method has been proposed, having a first step of polishing the copper or copper alloy and a second step of polishing the barrier layer conductor. In this two-step method, and in particular in the second step of polishing the tantalum-containing material, used for the barrier layer, it is important to polish the barrier layer without thinning the silicon dioxide film, and also while avoiding dishing of copper-containing material of the wiring. Note, in particular, the paragraph bridging pages 6 and 7 of Applicants' specification.

Against this background, and as a result of extensive studies performed by the present inventors, the inventors have discovered that the polishing of the tantalum-containing materials proceeds with ease when the polishing medium has both a low pH and the oxidizing agent is included in the medium in a low

concentration. Thus, according to the present invention, Applicants provide a polishing medium having specified components, including an oxidizing agent and a protective-film-forming agent, wherein the polishing medium has a pH of 3 or less and the oxidizing agent is included in a concentration of from 0.01-3% by weight, achieving objectives of the present invention of a relatively high polishing rate of the material of the barrier layer, while avoiding dishing and thinning, respectively, of the, e.g., copper wiring and of the oxide insulator, and which additionally can avoid scratches from occurring in the wirings. Thus, as described on pages 8 and 9 of Applicants' original disclosure, the present inventors have discovered that the polishing of the tantalum, tantalum alloy, tantalum nitride and other tantalum compounds which are used as the barrier layer, proceeds with ease in a low pH range and where the oxidizing agent is included in the medium at a low concentration. Moreover, at such low pH and low concentration of the oxidizing agent, etching rate of copper or copper alloy does not increase, avoiding dishing problems.

More specifically, as described in the sole full paragraph on page 16 of Applicants' specification, in general when the polishing medium has a pH of less than 3, etching rate of the copper or copper alloy film is so high as to make it difficult for the protective-film-forming agent to control the etching. However, in the present invention, the concentration of the oxidizing agent is so sufficiently low that the protection-film-forming agent can control the etching.

Furthermore, by utilizing abrasive grains having an average particle diameter as in various of the present claims, the polishing rate of silicon dioxide is decreased, avoiding any "thinning" problems. See the paragraph bridging pages 21 and 22 of Applicants' specification.

As for unexpectedly better results achieved according to the present invention, attention is respectfully directed to the aforementioned Declaration under 37 CFR 1.132, and in particular the Experiments described therein and experimental results set forth therein.

As seen in Additional Experiment 1 on pages 1-4 of the Declaration, Chemical A, within the scope of the present invention, achieved a high removal rate of tantalum nitride and tantalum as compared to the removal rate of copper and silicon oxide, while Chemicals B C, outside the scope of the present invention, had higher rates of polishing of copper and also had relatively low polishing rates of the tantalum-containing materials. Additional Experiment 2 on pages 5 and 6 of the Declaration shows that with use of a polishing medium according to the present invention, including abrasive grains, the removal rate increased with decrease of abrasive size, which is unexpected (removal rate increasing with increased abrasive size using chemicals outside the scope of the present claims, or in removing silicon oxide using Chemical A within the scope of the present claims or Chemical B outside the scope of the present invention).

In Additional Experiment 3 on pages 7 and 8 of the Declaration, it can be seen that a high removal rate of tantalum nitride and tantalum, as well as improved selectivity of removing tantalum-containing compounds as compared with copper, is achieved at relatively low pH within the scope of the present claims. Additional Experiment 4 on pages 9 and 10 of the Declaration shows that at relatively low oxidizing agent concentration (a concentration of less than 3% by weight), polishing rate of tantalum and tantalum nitride are relatively high, as compared with concentrations over 3% by weight; and selectivity for removal of tantalum-containing

compounds as compared with polishing of copper can be achieved at relatively low oxidizing agent concentration.

Additional Experiment 5 on pages 11 and 12 of the Declaration shows that with polishing media containing a water-soluble polymer (polyacrylic acid ammonium salt), decreased oxidizing agent concentration achieves increased removal of tantalum-containing materials, contrary to expectation; and, moreover, at low oxidizing agent concentration, a selectivity for removal of tantalum-containing material relative to removal of copper can be achieved. Additional Experiment 6 on pages 13 and 14 of the Declaration shows that decrease of pH can achieve a high polishing speed for tantalum and tantalum nitride materials, which is the opposite result achieved in connection with copper and titanium nitride films. That is, as seen in Additional Experiment 6, polishing speeds of the copper film and the titanium nitride film show behaviors completely different from that of the tantalum-containing film.

It is respectfully submitted that these Additional Experiments 1-6 show unexpectedly better results with respect to polishing of tantalum-containing materials, for polishing media as in the present claims having a relatively low pH and a relatively small amount of oxidizing agent, supporting unobviousness of the presently claimed invention.

Lee, et al. discloses a chemical-mechanical abrasive composition for semiconductor processing, which includes 70-95% by weight of an aqueous medium, 1-25% by weight of an abrasive and 0.1-20% by weight of an abrasion accelerator, the abrasion accelerator including a monocarboxy group- or an amido group-containing compound and optionally a nitrate salt. See column 2, lines 38-48. This patent goes on to disclose that the abrasive composition can further include 1-

15% by weight of, and preferably 4-8% by weight of, an oxidant. See column 2, lines 63-65. Note also column 3, lines 3-7 for specific oxidants. This patent further discloses that when used in a copper production process, the abrasive composition may include benzotriazole and/or its derivatives to inhibit rapid copper corrosion. See column 4, lines 13-20. Note also column 4, lines 30-40, for a disclosure of adjustment of the pH, with respect to polishing various materials. These various materials include copper and tungsten, but do not include tantalum, tantalum alloys or tantalum compounds. Note also specific compositions in the Examples.

It is respectfully submitted that Lee, et al. would have neither taught nor would have suggested the combination of relatively low pH and relatively low amount of oxidizing agent, and advantages thereof, e.g., in polishing tantalum-containing materials with a high polishing rate, and/or with selectivity relative to polishing copper-containing materials and/or silicon oxide.

Note that the Examples in Lee, et al. disclose adjustment of the pH of the slurry to have a pH of about 3.8 (in Example 1) and to have a pH of about 2.2 (in Example 3). Comparative Example 1 of Lee, et al. also discloses adjustment of the pH to have a pH of about 2.2. Moreover, Lee, et al. discloses that polishing tantalum is difficult. See, for example, column 6, lines 56-61 of Lee, et al. But note, also, Table 3 in column A of Lee, et al. Taking the teachings of Lee, et al. as a whole, it is respectfully submitted that such teachings do not disclose nor would have suggested, advantages achieved as in the present invention, realizing a relatively low concentration of oxidizing agent and relatively low pH.

Moreover, note that Table 3 of Lee, et al., which shows tantalum removal rate, shows such removal rate in connection with Examples 4-8 and Comparative Example 2. However, note that Examples 4-8 refer to the same preparation steps as

in Example 1, in which the slurry was adjusted to have a pH of about 3.8. It is respectfully submitted that Lee, et al., either alone or in combination with the teachings of the other applied reference, would have neither disclosed nor would have suggested such pH as in the present claims for polishing of tantalum, much less the combination of pH and oxidizing agent concentration as in the present claims and advantages thereof.

It is respectfully submitted that the teachings of the secondary reference as applied by the Examiner, Hardy, et al., would have not have rectified the deficiencies of Lee, et al. such that the presently claimed invention as a whole would have been obvious to one of ordinary skill in the art.

Hardy, et al. discloses a family of working liquids useful in modifying exposed intermediate surfaces of structured wafers for semiconductor fabrication, the working liquid being a solution of initial components comprising an oxidizing agent; an ionic buffer; a passivating agent; a chelating agent selected from iminodiacetic acid and salts thereof; and water. This patent discloses that the passivating agent may be an azole derivative preferably selected from benzotriazole, tolyltriazole or combinations thereof. See column 3, lines 40-45. See also column 7, lines 19-30; and column 7, line 64 to column 8, line 2. Note also column 9, lines 30-33; and column 9, line 67 to column 10, line 3, disclosing that the average particle size of inorganic particulates, included in the working liquid to increase removal rate of the metal and/or dielectric, to be less than about 1000 Angstroms. See also, column 10, line 9, disclosing amount of the inorganic particulates in the working liquid.

Even assuming, arguendo, that the teachings of Hardy, et al., were properly combinable with the teachings of Lee, et al., it is respectfully submitted that these combined teachings would have neither disclosed nor would have suggested such

polishing medium as in the present claims, having pH and concentration of oxidizing agent, and having size of the abrasive which achieves advantages according to the present invention as discussed previously, and as shown e.g., in Additional Experiment 2 in the afore-mentioned Declaration submitted in the above-identified application.

The contention by the Examiner in the paragraph bridging pages 2 and 3 of the Office Action mailed August 11, 2005, that oxidizing agent concentration and pH are result-effective variables because Lee, et al. shows there are concentration and pH ranges; and that, therefore, it would have been obvious for one skilled in the art to determine the oxidizing concentration and pH through routine experimentation to provide an optimum concentration and pH for the polishing composition depending of the material being polished, is respectfully traversed. It is respectfully submitted that Lee, et al. does not disclose, nor would have suggested, modifying combination of pH and oxidizing agent concentration, as in the present claims.

Moreover, it is respectfully submitted that the Declaration previously submitted, as well as disclosure in Applicants' original Specification and examples therein, show unexpectedly better results achieved according to the present invention, with pH and oxidizing agent concentration as in the present claims.

It is respectfully submitted that this evidence of unexpectedly better results overcomes any possible *prima facie* case of obviousness established by the Examiner, clearly establishing unobviousness of the claimed subject matter.

The contention by the Examiner that the composition of Lee, et al. would have the polishing-ratio between different materials recited in claims 37, 38, 51 and 52, the Examiner contending that the composition includes the same compounds with the same concentrations as that of the present claims, set forth in the third full

paragraph on page 3 of the Office Action mailed August 11, 2005, is noted. While there is overlap between various concentrations/pH, it is respectfully submitted that the Examiner has not established that compositions as in Lee, et al., would always (that is, inherently) have the polishing-rate ratio as in the present claims, or advantages achieved thereby.

The Examiner has not given patentable weight to the polishing of the barrier layer of Ta, Ta alloy or Ta compound, or polishing of a surface having at least one of Ta, Ta alloy and a Ta compound, "because the recitation occurs in the preamble". See Items 4 and 5 on pages 4 and 5 of the Office Action mailed August 11, 2005. Note that the claims have been amended to recite the capability of performing the polishing of the recited materials, as a property of the medium, set forth in the maIN body of the claims. Clearly, such recitations must be considered in determining patentability of the present claims; and, moreover, it is respectfully submitted that the Declaration previously submitted, as well as evidence in Applicants' specification, must be considered in determining patentability of the presently claimed subject matter.

In view of the foregoing comments and amendments, reconsideration and allowance of all claims presently in the application are respectfully requested.

If the Examiner believes that there are any matters which can be resolved by way of either a personal or telephone interview, the Examiner is invited to contact Applicants' undersigned attorney at the number indicated below.

Applicants request any shortage or excess in fees in connection with the filing of this paper, including extension of time fees, and for which no other form of payment is offered, be charged or credited to Deposit Account No. 01-2135 (Case: 566.41191X00).

Respectfully submitted,

ANTONELLI, TERRY, STOUT & KRAUS, LLP

By _____
William I. Solomon
Registration No. 26,565

WIS/vvr/ksh
1300 N. Seventeenth Street
Suite 1800
Arlington, Virginia 22209
Tel: 703-312-6600
Fax: 703-312-6666